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(71) Applicant(s)
Process Scientific Innovations Limited

(Incorporated in the United Kingdom)

Industrial Estate, Bowburn, Durham, DH6 5AD, United Kingdom

(72) Inventor(s)
Alex George Hunter
John Powell

(74) Agent and/or Address for Service
Beresford & Co
2-5 Warwick Court, High Holborn, LONDON, WC1R 5DJ, United Kingdom

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GB 2261830 A GB 2033247 A GB 1603519 A

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(54) CONDUCTIVE FILTER

(57) A gas and vapour permeable outer layer 17 is provided that has a conductive surface coating, and is used in a filter 1 to reduce the risk of fire and/or explosion. The filter 1 may be used to separate hydrocarbons from a gas stream entering the separator 1 through inlet 11. As the gas/hydrocarbon mixture passes through the matrix layer 9, the hydrocarbons coalesce to form hydrocarbon droplets that are transported in the outer layer 17 to the base of the filter 1, where they can fall under gravity into a sump (not shown). Static electricity is prevented from building up on the outer surface 18 of the filter 1 due to the conductive coating that has been applied thereto and therefore, the risk of fire and/or explosion is reduced.

FIG. 1

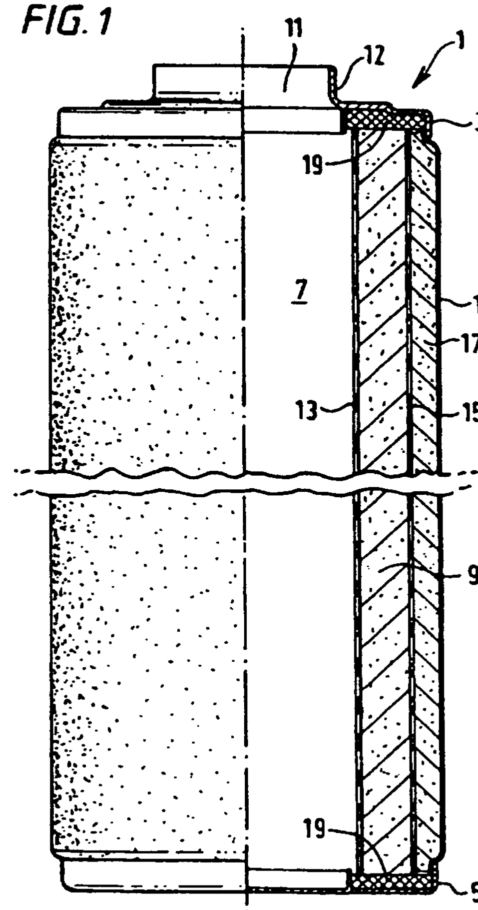

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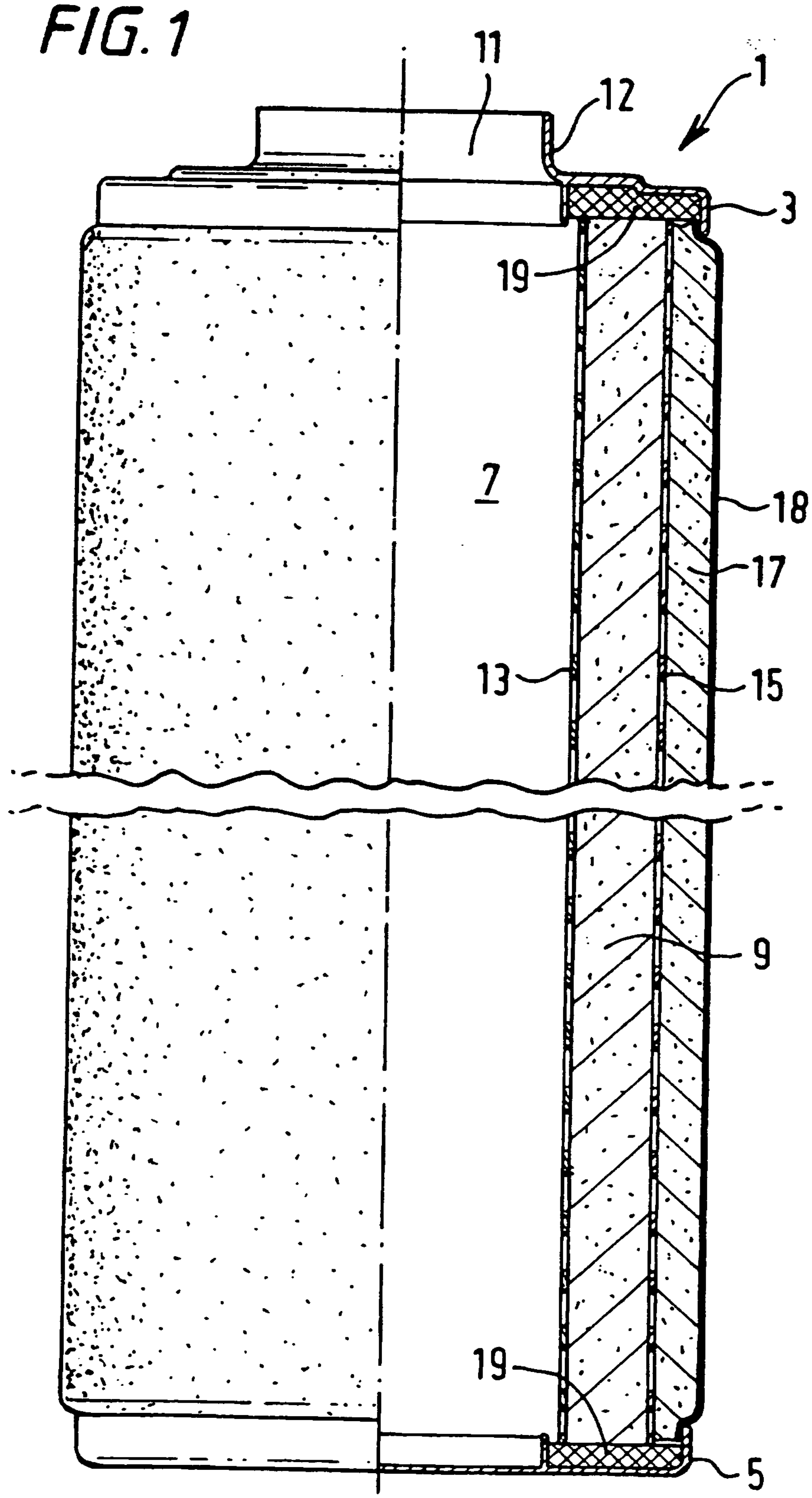
FIG. 1



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CONDUCTIVE FILTER

The invention relates to electrically conductive multilayer filters. The invention has particular relevance although not exclusive relevance to line filters, intake filters and separators used to separate hydrocarbons from gas streams.

In the compressor and vacuum pump market there is a requirement for electrically conductive filters (and separators), since the market believes that static build-up on the outside surface of the filter can eventually lead to levels where a spark can arc from the outside surface to the edge of the filter chamber. This spark may cause the filter to catch fire, or in some circumstances may even cause the filter to explode. It is believed that the static electricity builds up as the gas particles rub against the fibrous material of the filter walls as the gas passes therethrough.

The applicants have already proposed a solution to this problem by fitting an electrically conductive sleeve around the outside (relative to the direction of gas flow) of the filter. The electrically conductive sleeve comprises a blend of 95% polyester fibres and 5% nylon fibres coated with carbon black (hereinafter referred to as epitropic fibres). This conductive layer has less than 10^8 ohm-cm resistivity which is sufficient to prevent static build-up on the outer surface of the filter (the resistivity must be below 10^{11} ohm-cm,

otherwise the static electricity will not dissipate). However, the resulting filter is expensive, the resistivity is relatively close to the upper limit and more importantly local non-conductive areas in the conductive layer, due to the small percentage of epitropic fibres, are inevitable in which static electricity may build-up. The conductivity which can be obtained using epitropic fibres is limited. Above a 5% epitropic fibre content the available improvement in conductivity is slight. The alternative possibility of obtaining higher conductivity by incorporating stainless steel fibres is not acceptable because of the risk of fibre shedding.

Furthermore, the inventors believe that the conductive nature of this layer depends on the concentration of epitropic fibres, and on the pore structure of the layer, i.e. the density of fibres in the layer. If increased conductivity is required then either more epitropic fibres must be used or the density of the layer must be increased. The latter approach is usually the only practical solution, due to the cost of epitropic fibres. However, when the density of the fibres in the layer is increased the size of the pores between the fibres is decreased, and the resulting layer is unable to act as a drainage layer for coalesced hydrocarbons, when the filter is used in a gas/hydrocarbon separator. Therefore, when the conductive layer of this type is used

in a gas/hydrocarbon separator, an additional polyester fluorocarbon impregnated drainage layer is needed to ensure efficient drainage of the coalesced hydrocarbons.

It is an object of the present invention to alleviate some of the problems with the known electrically conductive filters.

The present invention provides a filter comprising an outer layer of gas and vapour permeable material having, on at least the outer surface thereof, a conductive coating. Such an outer layer has the advantage of having lower electrical resistance on its treated surface than that of the conductive layer made with the epitropic fibres, and has the further advantage that it is not prone to the development of local non-conductive areas.

When the filter is used in a gas/hydrocarbon separator, the outer layer may be used in conjunction with, or instead of, a liquid coalescing drainage layer. When used instead of the drainage layer, it is advantageous to treat the outer layer with a fluorochemical treatment that promotes free drainage of the coalesced hydrocarbons.

The inventors have also established, through experimentation, that a filter embodying the present invention is more efficient at separating the contaminating hydrocarbons from the gas stream than a filter without the conductive outer layer. It is

believed that this may be due to the absence of charge on the drainage layer, permitting both negatively and positively charged particles to coalesce freely.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawing in which:

Figure 1 schematically shows, in cross-section, an example of a conductive filter embodying the present invention.

The filter, generally indicated by reference numeral 1, in Figure 1 has a cylindrical body and comprises conductive gas impermeable end plates 3 and 5, which in this embodiment are made from mild steel pressings which are subsequently plated with zinc. Alternatively, the end caps 3 and 5 may be made of moulded conductive polybutylene terephthalate filled with 30% carbon fibres to ensure conductivity. Plastic end caps may be preferred in some embodiments where resistance to chemical corrosion is required. End cap 3 has an opening 11 defined by an upstanding collar 12, for allowing the filter to be attached to an associated filter head forming part of a filter head and filter chamber assembly. An interior space 7 of the filter 1 between the end plates 3 and 5 is closed by means of a matrix layer 9, which is a cylindrical gas and vapour-permeable liquid coalescing medium. Suitable materials which could be used for the matrix layer 9 include: raw borosilicate

glass microfibre impregnated with a binding resin, or raw borosilicate glass microfibre paper medium impregnated with a binding resin. The binding resin employed is typically silicone, epoxy or phenolic. A more detailed description of the matrix layer can be found in UK Patent GB 1603519, the contents of which are hereby incorporated by reference. If desired on the internal and/or external face of the matrix layer 9, cylindrical foraminous metal sleeves 13 and 15 may be provided for support purposes.

Around the matrix layer 9 a cylindrical outer layer 17 is provided having a conductive outer surface 18. To prevent static build-up, the conductive outer surface 18 is in contact with the conductive endcaps 3 and 5, which are grounded through the metal body of the filter chamber. Preferably, the endcaps 3 and 5, the matrix layer 9, the foraminous sleeves 13 and 15 and the outer layer 17 are held together by a conductive resin 19 to ensure good electrical continuity between the conductive outer surface 18 and the endcaps 3 and 5. A suitable conductive resin which may be used is a methyl silicone polymer containing conductive additives R-2630 supplied by NuSil Technology, 1040 Cindy Lane, Carpinteria, CA 93013, U.S.A. Also a conductive polyurethane resin material containing carbon black is available from Ciba-Geigy.

In the present embodiment, the outer layer 17 is a cylindrical gas and vapour-permeable medium made from a

non-woven 50% nylon and 50% polyester sheet from Lantor UK Ltd., having a conductive surface treatment. Other suitable materials which could be used for the outer layer 17 include: 100% polyester needlefelt supplied by Webron Products Ltd. of Bury, Lancashire or a needle punched 100% polyester felt which is available from Edward W Andrew Ltd. It is also possible to use a foam for the outer layer 17, for example a polyester based foam with a PVC acrylic binder supplied by Vitec (Vitafoam Ltd). However, such foam layers can only operate at temperatures below about 60°C, whereas the polyester/nylon felts can operate at temperatures up to about 120°C.

The composition used to treat the surface of the outer layer 17 must provide, on drying or curing thereof, a coating which is sufficiently electrically conductive to discharge static electricity which is present on the outer layer 17. It should preferably be non-inflammable or of low combustibility to protect the outer layer 17 from damage by sparks. In this embodiment, the composition is for treating the outer surface 18 of the outer layer 17. Therefore, the viscosity of the composition should be such that when it is applied to the outer layer 17, it remains on the surface 18 of the outer layer 17, and does not soak into the body thereof. Furthermore, the composition deposited on the surface 18 should not result in a continuous film that is

impermeable to the gas stream. Ideally, the treatment should result in a deposit that forms a matrix of interconnected islands of the composition, leaving sufficient void space for the gas stream to pass through. In practice when a felt is used for the outer layer 17, it has been found that these islands tend to form around points where the fibres of the outer layer 17 cross. Therefore, the effective pore size of the surface will be influenced by the density of the fibre distribution in the outer layer 17.

One composition suitable for treating the surface 18 of the outer layer 17, and a method for its preparation will now be described.

(i) 20 parts Viton B50 (which is the trade name of a fluoroelastomer containing tetrafluoroethylene, hexafluoropropylene and vinylidene fluoride groups supplied by E.I. Du Pont de Nemours) were dissolved in 100 parts methyl ethyl ketone with mixing;

(ii) then there were added

(a) 20 parts particulate graphite;

(b) 35 parts methyl ethyl ketone;

(c) 1 part N,'N-dicynnamylidene-1,6 hexanediamine (which is a vulcanising agent supplied by E. I. Du Pont de Nemours); and

(d) 2 parts micronised zinc oxide.

Preferably, less than 5% of the graphite particles used are over 300 mesh BSS, less than 15% of the graphite

particles used are over 350 mesh BSS, and more than 85% of the graphite particles used are below 350 mesh BSS. Variations from this particle size distribution are possible provided that the intended conductivity properties are obtained. However, coarse graphite tends to give a grainy surface whereas too fine a graphite may result in the graphite platelets becoming separated by the binder.

The resulting mixture has a honey-like viscosity and is applied to the surface 18 of the outer layer 17 by a knife or bar coater with the outer layer moving at e.g. a speed of one meter per minute. As mentioned above, the viscosity of the composition is selected so that when it is applied to the fabric by a knife or bar, the composition remains generally on the surface of the fabric and is not absorbed into its depth. A correctly applied deposit should form a matrix of interconnected islands of the composition leaving sufficient void space for gas to pass through. The composition applied to the layer is then cured by blowing hot air onto the treated surface. Preferably the composition is cured by firstly blowing hot air at a temperature of about 125°C onto the surface for about 1 minute, and then blowing hot air at a temperature of about 175°C onto the surface for about 1 minute. Once treated, the resulting outer layer 17 has a surface resistance of about 1.5K ohms, which is approximately 3000 times less resistant than the

epitropic/polyester blend conductive sleeve.

The amount of graphite that should be added to the mixture should be between 3 to 30 parts. A minimum amount of 3 parts graphite ensures that the resistivity of the outer surface of the layer 17 is below 10^{11} ohm-cm. However, the maximum amount of graphite is only limited by practical considerations. In particular, as the graphite content is increased beyond 20 parts, the mixture becomes increasingly thick and unmanageable. Furthermore, there will eventually be insufficient resin present to bond all the graphite particles together, resulting in some of the graphite particles being given off. Therefore, for practical purposes the amount of graphite particles used in the composition should preferably not exceed about 25 parts.

The amount of solvent used in the mixture should be between 50 and 200 parts. However, the exact amount of solvent that is used is dependent on the required viscosity. For example, if the amount of solvent is near the lower end of the above range, then the mixture will be relatively thick and unmanageable, whereas if the amount of solvent is near the upper end of the above range, then the mixture will be relatively thin. Therefore, the amount of solvent required depends on how the outer layer 17 is to be treated, i.e. surface treated or treated throughout the layer.

Although one composition (and a method for its

preparation) has been described, those skilled in the art will appreciate, that other compositions made with different solvents and vulcanising agents may be suitable for treating the outer layer 17. For example the graphite particles may be mixed with other fluoroelastomers, for example those containing hexafluoropropylene and vinylidene fluoride groups, and a suitable vulcanising agent that will give adequate cure under practical process conditions. It is also possible to omit the vulcanising agent when using a fluoroelastomer monomer, although such a composition will suffer from a low softening temperature and reduced chemical resistance.

Essentially, any elastomer, flexible plastic or other material may be used if it possesses the following properties:

(a) it can be dissolved or made (or exists as) a dispersion or emulsion;

(b) it does not require process heat above the resistance of the outer layer 17 or supporting fabric;

(c) it has a low level of combustibility;

(d) it is resistant to chemicals or solvents likely to be in the gas stream being filtered; and

(e) it has sufficient heat resistance to handle any hot gases being filtered.

Other elastomers or flexible plastics which could be used as alternatives to fluoroelastomers include

chlorinated ethylene rubber such as "neoprene" and "hypalon", other chlorinated rubbers, butyl rubbers, nitrile rubbers and the like or silicone elastomers. The elastomer or flexible plastic may be employed in solution in a solvent or in a water emulsion.

Graphite particles were used to make the cured composition conductive and are preferred because their natural "platelet" structure encourages electrical contact between particles. However, other particles such as carbon black, metallic powders or even conductive synthetic pigments may be used.

The outer layer 17 shown in Figure 1 is mounted on the outside of the matrix layer 9 with the conductive surface 18 on the outside. The outer layer 17 is mounted in this manner because the filter shown is designed for use as an in-to-out type filter, i.e. gas flows from the interior 7 to the exterior, and therefore the static electricity produced will accumulate on the external surface of the filter 1. If, on the other hand, the filter is designed for use as an out-to-in type filter, i.e. gas flows from the exterior to the interior 7, then the layer 17 should be placed on the inside of the filter 1 with the conductive surface 18 thereof, forming the inside surface of the filter. Alternatively, a conductive layer may be placed on the inside and the outside of the filter, to allow the filter to be used as an in-to-out or an out-to-in type filter.

In the conductive filter already proposed by the present applicant, a separate drainage layer and conductive layer are provided when the filter is used to separate hydrocarbons from a gas stream. This is not necessary when the above conductive outer layer 17 is used, since the density of the fibres in the outer layer 17 does not affect to the same degree the conductivity of the layer. Therefore, the pore size between the fibres can be made relatively large so that the outer layer 17 can also act as a drainage layer for the coalesced hydrocarbons. When the filter is used in a gas/hydrocarbon separator, the outer layer 17 is preferably treated with a fluorochemical treatment to enhance its efficiency as a drainage layer. A suitable fluorochemical treatment is disclosed in EP-B-0487519, the contents of which are hereby incorporated by reference.

The inventors have established through experimentation, that when an embodiment of the filter shown in Figure 1 was used to separate hydrocarbons from a gas stream, not only was it less susceptible to static build-up, but it was also more efficient at removing hydrocarbons from the gas stream, than a filter without a conductive layer.

In particular, in one experiment the inventors connected a filter having a non-conductive outer layer to an oil lubricated vacuum pump, and measured the amount

of hydrocarbons that were contained in the gas stream upon leaving the filter. Then they replaced the non-conductive outer layer with the conductive outer layer described above and took the same measurements. They found that when a non-conductive outer layer was used, the hydrocarbon carry-over was about 3.8mg/m^3, whereas when the conductive outer layer was used, the hydrocarbon carry-over was about 3.48mg/m^3. The inventors believe that the reason for this increase in efficiency may be due to the absence of charge on the drainage layer, permitting both negatively and positively charged hydrocarbon particles to coalesce freely.

In the above embodiments, only the outer surface 18 of the outer layer 17 is coated with a conductive coating. However, those skilled in the art will realise that both the inside and the outside surface of the outer layer 17 may be treated. Additionally, it is also possible to vary the viscosity of the conductive composition, such that when it is applied to the outer layer it soaks into the body of the outer layer, thereby making the entire outer layer conductive. However, in such an embodiment, care should be taken to ensure that the outer layer maintains its permeability and drainage characteristics.

CLAIMS

1. A multilayered cartridge filter intended in use to be subject to unidirectional flow wherein the last layer, relative to the direction of flow has a conductive coating on at least the outer surface thereof.

2. A filter according to claim 1, wherein the conductive coating comprises conductive particles dispersed in a resin.

3. A filter according to claim 2, wherein said conductive coating comprises between 3 and 30 parts of conductive particles.

4. A filter according to claim 2 or 3, wherein the resin comprises a heat or chemically resistant elastomer.

5. A filter according to claim 2 or 3, wherein said resin comprises a fluoroelastomer.

6. A filter according to any of claims 2 to 5, wherein said conductive coating is the result of curing the resin <u>in situ</u> by means of a cross-linking or vulcanising agent.

7. A filter according to any of claims 2 to 6, wherein

said conductive particles include one or more of: graphite particles, carbon black particles, metallic powder or conductive synthetic pigments.

8. A filter according to any preceding claim, wherein said filter is a coalescing filter.

9. A filter according to claim 8, wherein said coalescing filter comprises at least one coalescing layer and wherein said last layer is a drainage layer.

10. A filter according to claim 9, wherein said last layer is treated with a fluorochemical treatment.

11. A filter according to claim 9 or 10, wherein said layers are cylindrical and are closed at the ends by means of impermeable end plates.

12. A filter according to claim 11, wherein said conductive coating is on the inside of the cylindrical filter.

13. A filter according to claim 11, wherein said conductive coating is on the outside of the cylindrical filter.

14. A filter according to claim 11, wherein both faces

of the cylindrical filter are conductively coated.

15. A filter according to claim 11 wherein, conductive material is through the body of the cylindrical filter but is applied so as not to adversely affect the porosity thereof.

16. A filter according to any of claims 9 to 15, wherein there is provided a second drainage layer between said last layer and said at least one coalescing layer.

17. A filter according to any preceding claim, wherein only one surface of said last layer has said conductive coating.

18. A filter according to any preceding claim, wherein said coated surface has a resistivity less than 10^{11} ohm-cm.

19. Use of a filter according to any preceding claim, as a line filter.

20. Use of a filter according to any preceding claim, as an intake filter.

21. Use of a filter according to any preceding claim, to separate hydrocarbons from a gas/liquid stream.

22. A multilayered filter substantially as described herein with reference to the accompanying drawing.

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The Patent Office

Application No: GB 9509067.6
Claims searched: 1-22

Examiner: Dr. A.J.Rudge
Date of search: 28 July 1995

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.N): B1T(TDAA,TDPA,TDQA,TDRA,TDRB,TPMA)

Int Cl (Ed.6): B01D-029/58;046/24;053/72

Other: ONLINE DATABASES: WPI,CLAIMS,EDOC,WPIL

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB2261830A (Process Scientific)	1-22
A	GB2033247A (" ")	"
A	GB1603519 (" ")	"

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.